ELECTRO-OPTICAL DEVICE, ELECTRONIC DEVICE, AND ILLUMINATION APPARATUS INCLUDING A PANEL HAVING AN ELECTRO-OPTICAL LAYER

BACKGROUND

1. Technical Field

The present invention relates to an electro-optical device, an electronic device, and an illumination apparatus.

2. Related Art

Flat-panel displays for use in thin television sets and mobile phones are required to be of low profile and light weight. In recent years, flexible flat-panel displays have been proposed to develop new markets.

For example, JP-A-2005-19082 discloses an organic EL display that includes an organic electroluminescence (EL) layer between two glass substrates each having a thickness as small as 100 μm or less. JP-A-2005-19082 also discloses that the organic EL display may include resin reinforcing layers on outer surfaces of the front and back glass substrates to compensate for the insufficient strength resulting from the reduced thickness.

As illustrated in FIG. **34**, Japanese Patent No. 4,131,639 discloses a liquid crystal display **400** that includes a liquid crystal panel **90** composed of a pair of thin glass substrates sandwiched between transparent resin films **95***a* and **95***b*.

The liquid crystal panel **90** is of a reflective type and is provided with a polarizing plate **91**, which also serves as a reinforcing plate, on the display screen side and with a resin reinforcing plate **92** on the back side. The liquid crystal panel **90** with the resin reinforcing plates **91** and **92** attached on both sides is disposed between the two resin films **95***a* and **95***b*.

It is considered that the reinforcing structure including the reinforcing plates **91** and **92** and the resin films **95***a* and **95***b* is intended to compensate for the specific characteristics of the glass substrates, that is, relatively high resistance to compressive stress but very low resistance to tensile stress. Japanese Patent No. 4,131,639 also discloses that the reinforcing structure is applicable to EL panels.

However, it is difficult to achieve sufficient actual strength with the reinforcing structure that includes the resin reinforcing plates **91** and **92** and the resin films **95***a* and **95***b*. In other words, it is difficult for the liquid crystal display **400** to achieve both great flexibility and high actual strength (tenacity).

This is because the resin reinforcing plates **91** and **92** and the resin films **95***a* and **95***b* disposed on the glass substrates may bend along with the glass substrates upon the application of a bending stress. In other words, the reinforcing plates **91** and **92** and the resin films **95***a* and **95***b*, together with the glass substrates, may be easily bent to the breaking point of the glass substrates (limiting radius). Thus, the glass substrates may become cracked and broken.

With the reinforcing structure in which the liquid crystal panel **90** with the reinforcing plates **91** and **92** attached on both sides is disposed between the two resin films **95***a* and **95***b*, not only dose the liquid crystal display **400** have a large thickness, but a gap G is also formed around the liquid crystal panel **90**.

The gap G is particularly troublesome in a reinforcing structure that includes an organic EL panel as a display panel. More specifically, the formation of a large gap G around an organic EL panel may allow moisture to intrude into the gap G, causing deterioration of the organic EL layer. Since organic EL panels are self-luminous devices, display on a screen causes heat generation. However, heat radiation is not taken into consideration at all in the reinforcing structure. In other words, it is difficult for the reinforcing structure to prevent deterioration of the organic EL panel caused by heat generation.

SUMMARY

The invention has been achieved to solve at least part of the problems described above and can be implemented in accordance with the following embodiments or aspects.

Aspects

An electro-optical device that includes a display panel having an electro-optical layer, a first resin film stacked on the display panel to cover a first surface on the side of a display area of the display panel, and a second resin film stacked on the display panel to cover a second surface opposite the first surface, and at least one reinforcing member disposed on at least one of the first resin film and the second resin film.

Since this electro-optical device has a structure in which a reinforcing member is disposed on the outer surface of at least one of the first resin film and the second resin film, the first resin film and the second resin film can be stacked with a smaller gap around the display panel, thereby improving sealing properties. The electro-optical device has a smaller thickness than a known display in which a reinforcing plate is attached to the front and back sides of a display panel.

In an electro-optical device according to another aspect, a first reinforcing member disposed on the first resin film has an opening corresponding to the display area of the display panel.

Since the first reinforcing member has an opening corresponding to the display area of the display panel, a reduction in the visibility of the display panel can be prevented even if the first reinforcing member is formed of a material that reduces visibility. The electro-optical device that includes such a reinforcing member having an opening can include a portion having a reduced thickness and can therefore be bent more easily than a conventional structure that includes no opening.

The at least one reinforcing member has a multilayer structure that includes a first carbon fiber layer and a second carbon fiber layer. The first carbon fiber layer contains a plurality of carbon fibers extending in a first direction. The second carbon fiber layer contains a plurality of carbon fibers extending in a second direction. The first direction and the second direction cross each other. The at least one reinforcing member two-dimensionally surrounds the display area of the display panel.

Since the at least one reinforcing member has a multilayer structure that includes the first carbon fiber layer containing a plurality of carbon fibers extending in a first direction and the second carbon fiber layer containing a plurality of carbon fibers extending in a second direction, which crosses the first direction, the first and second carbon fiber layers can increase the tensile strength of the at least one reinforcing member in any two-dimensional direction, thereby preventing a substrate on which an electro-optical layer is formed from being bent to the breaking point (limiting radius) even when a bending stress is applied to the substrate in any direction.

Carbon fiber is manufactured by carbonizing long fiber at high temperatures of 1000° C. or more to high purity. The long fiber can be made of polyacrylonitrile (PAN) or pitch. Carbon fiber has high tensile strength, a low thermal deformation ratio (a low coefficient of linear expansion), and high thermal conductivity. Such carbon fiber can be combined with a binder resin, such as an epoxy resin, to manufacture carbon-fiber-reinforced plastics (CFRPs). A reinforcing member containing a carbon-fiber-reinforced plastic (CFRP)